

Effect of Temporal and Spatial Environmental Variability on Littoral ASW Search Tactics

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LONG-TERM GOAL

Our long-term goal is to continue to assess the impact of temporal and spatial dynamics of oceanographic and meteorological factors on Navy sensors, systems, and operations. We will continue to improve our ability to exploit advances in remote sensing and climatology in the development of environmentally sensitive algorithms to improve ASW effectiveness in shallow-water, littoral regions. We intend to more closely integrate this technology with acoustic propagation and sonar performance prediction models whose ultimate application of these technologies is to provide sensor track optimization. Current work has focused on the Genetic Algorithm to solve the optimal search path problem. We have had sufficient success in two SHAREM exercises to warrant further development of the GA in the areas of target motion modeling, multiple constraint measures of effectiveness and user interface issues.

OBJECTIVES

The objective of our FY99 effort was to continue to quantify the sensitivity of acoustic processes and sensor performance in the littoral zone to temporal environmental variations. A key question to be addressed is "Can improvements in sonar search performance be gained through the incorporation of in-situ data to improve ocean climatology?"

APPROACH

Our approach during FY 99 has been as follows. First, an appropriate environmental grid was constructed and populated with high-resolution environmental data, including Modular Ocean Data Assimilation System (MODAS) fields. Also collected was standard climatology for use as a baseline comparison, as well as all relevant bathymetric and geoacoustic data for the area. Second, an ASW scenario was defined and sensor/threat data were collected. Third, acoustic sensor performance was calculated for every grid point along several radial directions, which was then converted to signal excess. Fourth, "optimum" ASW search tactics were generated using genetic algorithms based on performance estimates from MODAS fields and from climatology. Last, the results were analyzed and evaluated in terms of cumulative probability of detection as the Measure of Effectiveness (MOE). A

critical aspect of the present effort is to develop recommendations for further study, including a generalization of the results to other ocean areas.

WORK COMPLETED

Although work is still in progress, results to date have been quite encouraging and provide considerable guidance with respect to the validity of the temporal and spatial assumptions used to develop the conceptual model. Furthermore, a firm foundation has been developed that is critical to answering the question of how often a tactic should be changed based on dynamic environmental conditions.

RESULTS

We participated in the SHAREM 127 Exercise to obtain field data for this study. During the sea test, MODAS data were collected to analyze the impact of daily environmental variations on sensor and systems performance predictions.

Test results are encouraging and validate assumptions of the conceptual model. The figure below shows environmentally sensitive optimal ships tracks, generated during SHAREM 126.

The figure shows the optimal track overlaying a graphic representation of the performance of the 53C sonar, where detection area in radial wedges about each grid point is depicted by color. Red denotes good area coverage ranging between 30 and 45 nm². Green denotes moderate area coverage between 15 and 30 nm². Poor performance is denoted by blue (0 – 15 nm²). The starting point for each track is the lower left-hand corner of the plot.

In Figure 1a tracks optimized for a target at 60-m depth show a progression of three different days during the SHAREM. These tracks were generated using the daily MODAS nowcast, and while even though a storm passed through the area during this period, variability in the sonar performance is small. In general, for targets at this depth, detection is not good owing to the downward refracting sound speed profiles typical of this season. However, the genetic algorithm shows its utility in providing search tactics for these conditions.

Closer to the surface, things are quite different. Figure 1b shows a similar progression of sonar performance for a target at 18 m, for three different days, during a storm passage. The left-hand plot shows a fairly homogeneous, low performance on Julian Day 257 just before the storm. Without a mixed layer, there is a downward refracting gradient near the surface. The GA again helps to find a best path for detection in this difficult environment. Four days later, a storm has come into the area and a mixed layer starts to form. The non-uniformity of this layer is apparent at the early stages of the storm giving areas of high detection to the north and south. The GA chooses a track, which concentrates search efforts within these areas. On Julian Day 265, after the storm has passed, mixing is uniform over most of the search area and the GA selects a ladder pattern as the most efficient tactic in this environment.

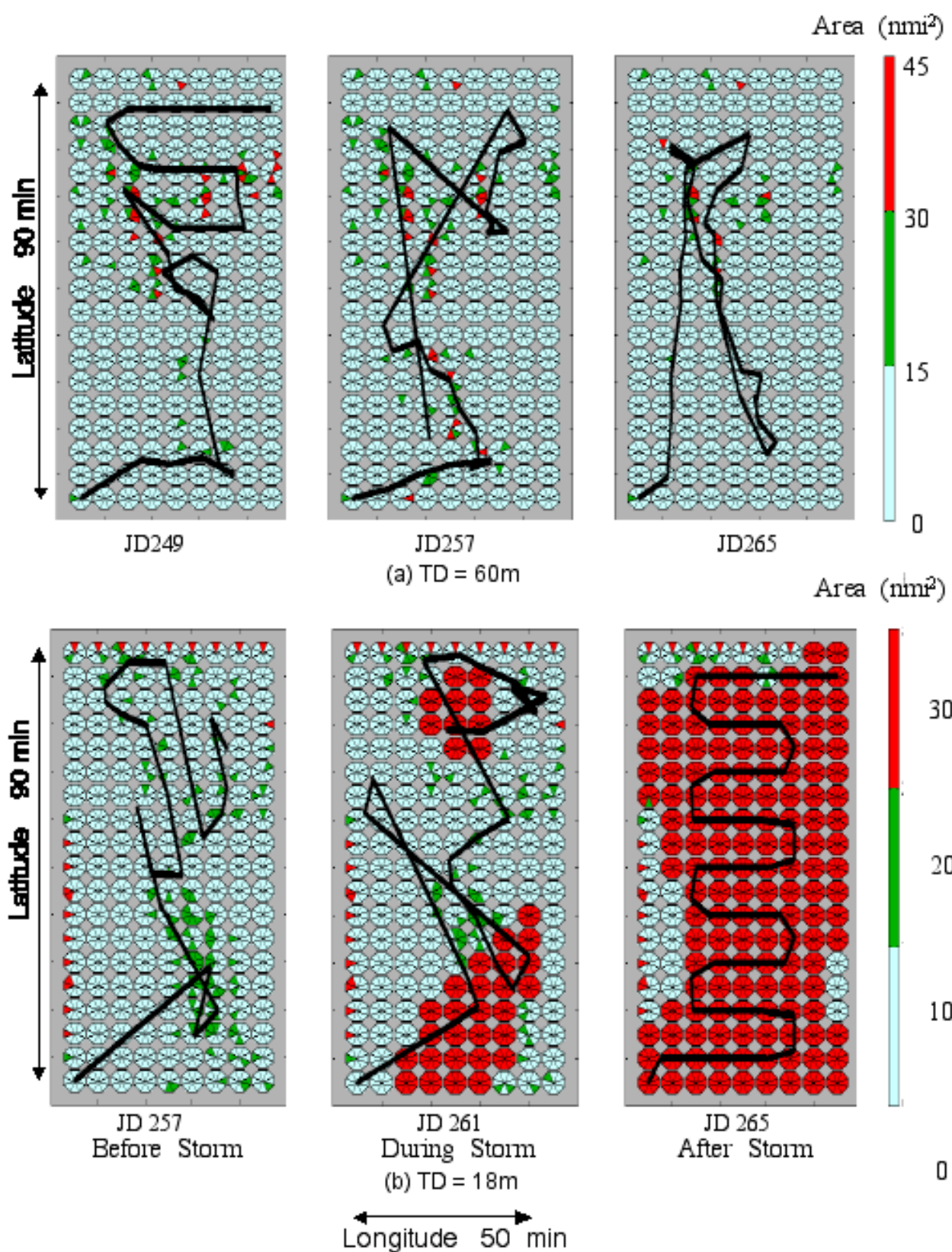


Fig. 1. Optimal tracks over plots of detection area.

IMPACT/APPLICATIONS

Development of a tactical search optimization tool that maximizes use of environmental information will provide valuable guidance in performance assessment and mission planning for antisubmarine and mine warfare activities. These optimization tools can be used to estimate effective performance gains achievable by intelligent tactics for comparison with performance gains obtainable by more expensive sensors and processing upgrades.

TRANSITIONS

Although transition of the present effort is pending, we envision the product to be integrated with CADRT and is being considered for inclusion in AUSWC. There are many other potential spin-off transitions, including the LBVDS and MACE programs.

RELATED PROJECTS

The present effort is related to several Tactical Decision Aids such as the Sonar In-Situ Mode Assessment System (SIMAS), Tactical Control Program (TCP), and the Integrated Carrier ASW Prediction System (ICAPS). It is also related to the IMAT program whose training features can be used to make tactical decisions.

REFERENCES

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PUBLICATIONS

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